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Analysis of Source Voxelization Methods Based on Space Partitioning for Dose Assessment Using Point-Kernel Method

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1. Introduction

The Point-kernel method is one of the representative methods that can perform external exposure dose assessment. The Point-kernel method allows for approximately dose assessment exposed by various shape of sources. For dose assessment using point-kernel method, the source should be voxelized to generate a set of point sources, and then a dose evaluation can be performed for each point source. Finally, the final dose assessment result can be derived by summing the results for each point source.

Source voxelization can be performed based on the space partitioning method to generate a set of point sources. However, the size and location of the voxel may vary depending on the space partitioning method. As a result, the distribution of the point sources and the number of point sources may vary depending on the space partitioning method, and the final dose assessment result and assessment time may also vary somewhat.

Therefore, an appropriate space partitioning method should be selected considering the accuracy of the results and the number of point sources generated, and it should be investigated and analyzed. In this study, we investigated the space partitioning methods for voxelization the source. Then, source voxelization methods based on each space partitioning methods were analyzed.

2. Analysis of space partitioning

2.1 K-d tree method

Fig. 1 shows an example of the K-d tree method for space partitioning. The K-d tree method has a data structure in the form of a tree diagram that contains 2 subdata for one datum [1]. Based on the space partitioning method for data structure of K-d tree method, a space can be partitioned into multiple spaces. The K-d tree method partitions a space using a plane that is orthogonal to the axis of the space. When partitioning a space, the longest side of the space is bisected to divide a space into 2 spaces.

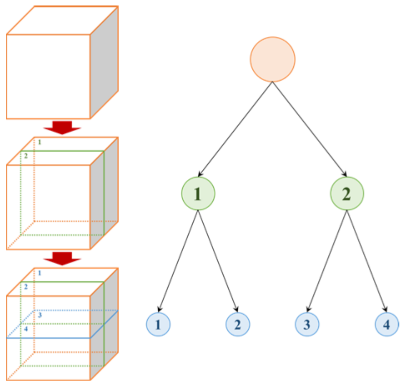

Fig. 1 K-d tree method for space partitioning

2.2 Oct-tree method

Fig. 2 shows an example of the oct-tree method for space partitioning. The oct-tree method has a data structure in the form of a tree diagram that contains 8 subdata for one datum [2]. Based on the space partitioning method for data structure of oct-tree method, a space can be partitioned into multiple spaces. The oct-tree method partitions a space using a plane that is orthogonal to the axis of the space. When partitioning a space, each side of the space is bisected to divide a space into 8 spaces.

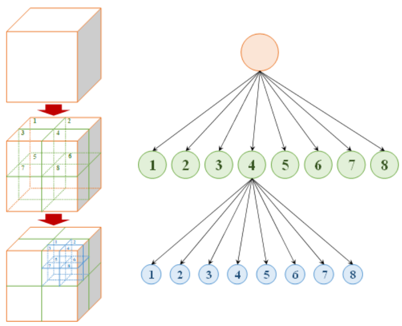

Fig. 2 Oct-tree method for space partitioning

3. Analysis of source voxelization methods based on space partitioning

In this step, we analyzed the method for voxelization a source based on the investigated space partitioning method. In general, source can be assumed to be a point source if the distance between the center of the source and the assessment point is sufficiently larger than the size of the source [3]. This allows the voxel to be considered as a point source, otherwise, the voxel is partitioned iteratively until there are no more voxels to partition.

3.1 Source voxelization based on K-d tree method

Fig. 3 shows an example of source voxelization procedure using the K-d tree method. In order to voxelize the source, the space occupied by the source must be established. The space is called a boundary space, and the size of the space can be set through the maximum length, width, and height of the source. In order to partition a boundary space, it is necessary to evaluate whether the space is assumed to be a point source. When partitioning a source based on the K-d tree method, the voxel is generated by bisecting the longest side of the boundary space. If the partitioned voxel cannot be assumed to be a point source, the voxel is further partitioned by bisecting its longest side. Compared to the oct-tree method, the boundary space is divided into fewer voxels, which are relatively various sizes. Therefore, when the voxel is assumed to be a point source, a relatively small number of point sources are generated and irregularly distributed.

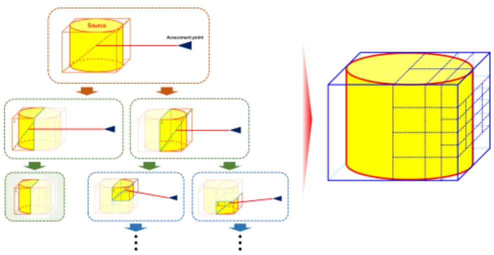

Fig. 3 Source voxelization procedure based on K-d tree method

3.2 Source voxelization based on oct-tree method

Fig. 4 shows an example of source voxelization procedure using the oct-tree method. A boundary space is established to voxelize the source. When partitioning a source based on the oct-tree method, the voxel is generated by bisecting each side of the boundary space. If the partitioned voxel cannot be assumed to be a point source, the voxel is further partitioned by bisecting its each side. Compared to the K-d tree method, the boundary space is divided into a larger number of voxels, which are relatively constant size. Therefore, when the voxel is assumed to be a point source, a relatively large number of point sources are generated and uniformly distributed.

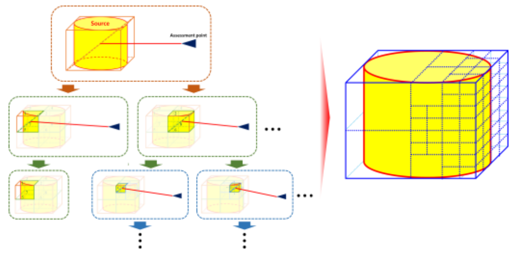

Fig. 4 Source voxelization procedure based on oct-tree method

4. Conclusions

In this study, we investigated the space partitioning methods for voxelization the source. Then, we analyzed source voxelization methods based on each space partitioning method.

The K-d tree method has been shown to voxelize a source by bisecting the longest side of the boundary space of the source. The Oct-tree method has been shown to voxelize a source by bisecting each side of the boundary space of the source. When generating a set of point sources through divided voxels based on each space partitioning method, the number of point sources and the distribution of point sources can be different. The results of this study can be used as a basis for external exposure dose assessment based on the point-kernel method.

ACKNOWLEDGEMENTS

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